Marine Geology 347 (2014) 58–68

Contents lists available at ScienceDirect

Marine Geology

journal homepage: www.elsevier.com/locate/margeo

Late Pleistocene cyclicity of sedimentation and spreading-center structure in the Central Gulf of California

Jared Kluesner [a,*], Peter Lonsdale [b], Antonio González-Fernández [c]

[a] Dept. of Earth and Planetary Sciences, University of California, Santa Cruz, CA, United States
[b] Scripps Institution of Oceanography, University of California, San Diego, La Jolla, CA, United States
[c] Centro de Investigacion y de Educacion Superior de Ensenada (CICESE), Ensenada, Baja California, Mexico

ARTICLE INFO

Article history:
Received 29 March 2013
Received in revised form 24 October 2013
Accepted 1 November 2013
Available online 9 November 2013

Communicated by D.J.W. Piper

Keywords:
Gulf of California
Guaymas Basin
spreading center structure
seismic stratigraphy
sedimentation
climate

ABSTRACT

The interaction between climatic-driven fluctuations in sediment supply and dynamic changes in basin physiography is a fundamental process of rift basin evolution that is poorly understood. A high-resolution seismic profile collected across the southern Guaymas Basin spreading center reveals how cyclical changes in sedimentation interact with on-going axial rifting and accretion of oceanic crust. The 4 km-wide axial rift valley abuts the steep, canyon incised continental slope of Baja California. Alternating acoustically transparent and well-layered high-amplitude seismic units imaged on the accreted flanks record the filling and regeneration of the axial rift over the past ~200 ka. An approximate correlation of seismic units to nearby Deep Sea Drilling Program (DSDP) Site 478 indicates that transparent units are composed primarily of diatomaceous silty mud turbidites, whereas the intervening well-layered high-amplitude units represent mud turbidites interlayed with terrigenous silty sand. Age estimates using sparse biostratigraphy and plate stratigraphy suggest deposition of transparent units coincident with interglacial/high-stands, while deposition of well-layered high-amplitude units corresponds to glacial/low-stands. Analysis of seismic stratigraphy and imaged faults reveals that during glacial/low-stands, deposition of terrigenous-rich turbidites out-paced axial spreading and subsidence, filling the axial rift and spilling over onto the adjacent basin floor. However, during interglacial/high-stands, reduction in sediment supply resulted in reestablishment of the axial rift relief. We propose that increases in sediment supply and terrigenous material during glacial periods were caused by a combination of (i) enhanced erosion of Baja California during pluvial periods, corresponding to northern hemisphere glacial maxima, (ii) increased delivery of sediment from the Sierra Madre Occidental, and (iii) sediment bypass on the continental shelf and slope to the deep-water basins during relative sea-level low-stands.

1. Introduction

Changes in the acoustic character of Quaternary-age seismic stratigraphy that correlate with orbitally forced glacial/interglacial cyclicity have been previously reported at mid-latitude sites of near-shore Pleistocene marine deposition. Perissoratis et al. (2000) described alternations of eustatic sea-level low-stand reflector-rich turbidites and high-stand seismically transparent muds in the bed of the Gulf of Corinth. Turbidite deposits were emplaced during eustatic low sea levels when the shallow sill separating that gulf from the Mediterranean was emergent, creating a fresh-water lake with under-flows of denser turbid river water (Perissoratis et al., 2000). Off the U.S. west coast across the Santa Barbara Basin, Peterson et al. (2009) correlated changes in seismic reflector amplitudes to orbital-to-sub orbital climate cyclicity. Weigelt and Uenzelmann-Neben (2007) correlated cyclicity of reflector strength in seismic profiles from the continental slope of southwest Africa with orbitally driven climatic variations, and proposed that the linkage there was via climatically controlled changes in plankton populations that changed the bulk density, and thereby the acoustic impedance of the biogenous slope sediment.

Perhaps the closest reported analog to the situation we describe in Guaymas Basin involves turbidites that onlap a tectonically tilted ocean-basin sediment blanket at 36–38° S in the Chile Trench. Several seismic profiles collected across the Chile Trench show four units with high amplitude internal reflectors, separated by units with much lower amplitudes, which are cross-correlated to orbital climate cycles (Rauch, 2005; Völker et al., 2006). Climatic changes affecting rates of denudation in the Andes are inferred to be the principal control of trench-floor cyclical stratigraphy, though Völker et al. (2006) suggested that seismogenic cycles provoking slumping of the continental slope could also be a factor.

Unlike other regions of observed seismic alternations discussed above, the Gulf of California is actively spreading, allowing us to develop a tectonostratigraphic framework to describe the geomorphic development of the rift basin. Lithologic constraints on seismic facies based on Deep Sea Drilling Program (DSDP) Leg 64, which also provide some

* Corresponding author.
E-mail address: jwkluesn@ucsc.edu (J. Kluesner).

0025-3227/$ – see front matter © 2013 Elsevier B.V. All rights reserved.
http://dx.doi.org/10.1016/j.margeo.2013.11.001

age control for testing the hypothesis that structural changes recorded by the seismic imagery were driven by climatic cyclicity and eustatic sea-level change. In addition, we apply a plate-stratigraphy technique similar to Rauch (2005) to further constrain the timing of deposition cycles. After describing the evidence for sedimentary and structural cyclicities at the Southern Trough of Guaymas Basin, we discuss how these patterns are potentially related to paleoclimate patterns and present a model for the development of the spreading axis structure.

2. Geological setting

The Gulf of California occupies part of a 1750 km-long oblique-divergent plate boundary, and is floored by an echelon series of post-Miocene oceanic basins that are surrounded by stretched and subsided continental crust (Lonsdale, 1989). Spreading centers located at basin axes are represented by three structural types (Fig. 1), in which each appears to accrete different types of oceanic crust. (1) The spreading axis in the southernmost (Alarcon) basin has a structure similar to that of the East Pacific Rise (EPR), with an elevated axial zone of eruptive fissural volcanism and extrusive upper-most crust (Castillo et al., 2002). (2) At the shallower northern end of the Gulf, spreading centers in Wagner and Upper Delfin Basins occupy broad depressions with gently inclined side-slopes interrupted by a few low-relief fault scarps (Persaud et al., 2003) and the upper crust is characterized by thick sections of sparsely intruded sediment sourced from the Colorado River (Dorsey, 2010). (3) Rift valleys or "axial troughs" mark all the seven gulf spreading centers between the northern and southern end members. The axial rifts are characterized by 3–5 km-wide troughs that are 150 m (Guaymas Basin) to −1200 m (Farallon Basin) below the adjacent basin floors. These narrow, enclosed depressions act as depocenters for sedimentary mass flows, especially turbidity flows (Einsele and Kelts, 1982). Focused accumulation of low-density turbidites above the axes of crustal accretion is inferred to hamper the rise, and particularly the eruption, of magma injected into the neovolcanic zones (Einsele, 1985). Therefore, the sedimentary blanket may be responsible for the distinctive sediment-sill composition of the oceanic crust accreted at these axes (Einsele, 1985), and for their distinctive structure (Moore, 1973).

Axial troughs in the Gulf of California were initially inferred to be short-lived, simple grabens created by local subsidence (Bischoff and Henyey, 1974). Even though most of them lack flanking sets of bilaterally symmetric magnetic anomalies, Einsele (1985) and Lonsdale and Becker (1985) proposed that the axial troughs occupy long-lived regenerating rifts, where newly accreted crust moves upwards and outwards from the trough floors (Atwater and Mudie, 1973; Tapponnier

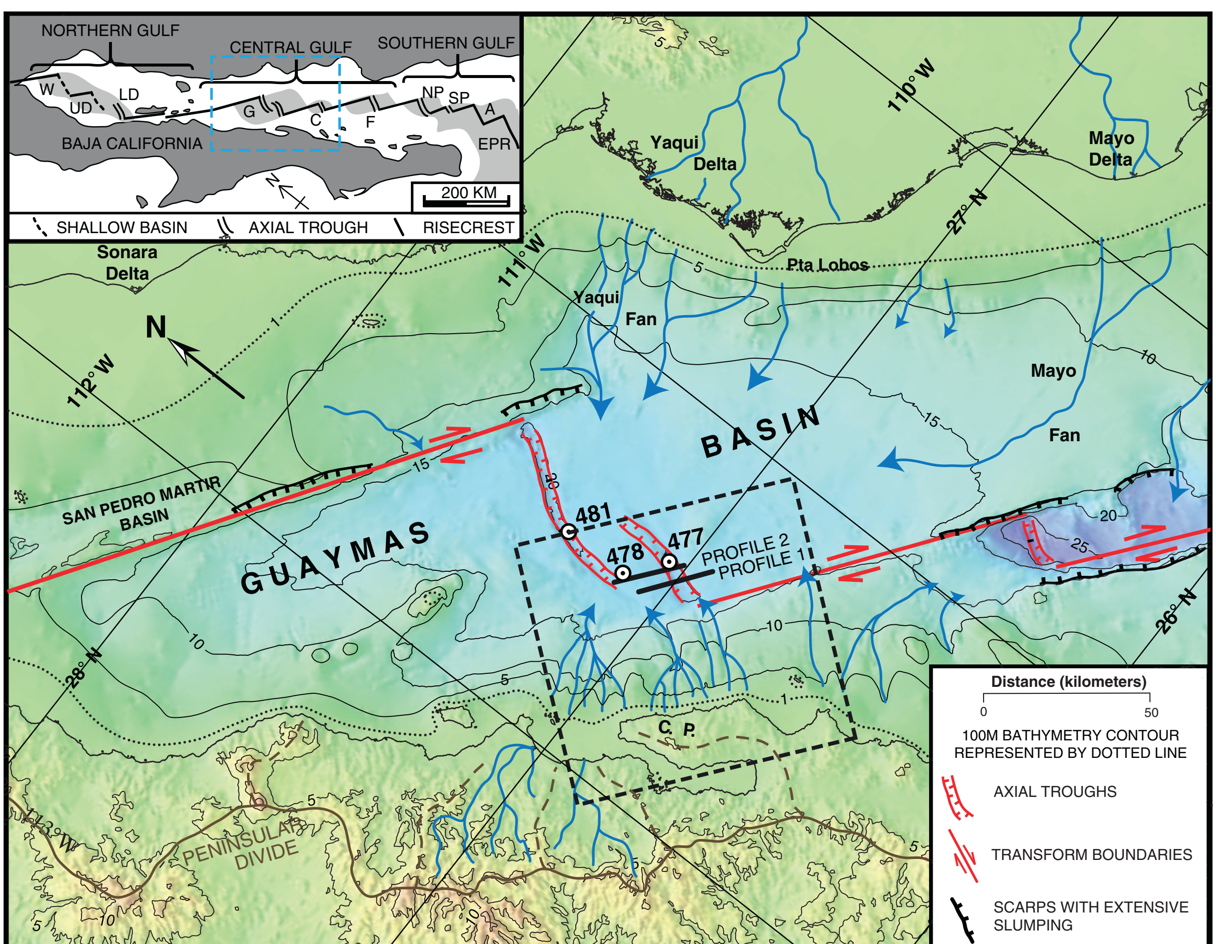

Fig. 1. Topography of Guaymas and Carmen Basins. Bathymetry is from multibeam surveys, supplemented in shallow water by contour interpolation of archival soundings; subaerial relief from satellite altimetry. Blue lines represent principal channels used for transport of terrigenous clastics: subaerial rivers, and submarine canyons, slope gullies, and fan channels. Brown lines on Baja California locate primary and secondary (dashed) drainage divides. Dashed black box locates the area shown in more detail in Fig. 2. Numbered circles locate DSDP coring sites discussed in the text. Labeled contours are in hundreds of meters (10 = 1000 m). C.P. = Concepcion Peninsula. Inset. Pattern of the plate boundary throughout the Gulf, with spreading centers labeled: W—Wagner, UD—Upper Delfin, LD—Lower Delfin, G—Guaymas, C—Carmen, F—Farallon, NP—North Pescadero, SP—South Pescadero, A—Alarcon, EPR—East Pacific Rise. Land is dark gray, newly accreted crust light gray; dashed blue box locates area of main map.